

REMARKS

The Office Action dated February 26, 2003 has been received and carefully noted. Applicants thank the Examiner for the multiple telephone interviews conducted regarding the present application. The above amendments to the claims, and the following remarks, are submitted as a full and complete response thereto. Claims 4-6, 8-14, 16-21, and 23-25 are allowed. Claims 1, 2, 5-7, 15, 22, and 26 are rejected. By this Amendment, claims 1 and 5 are amended. No new matter is added. Accordingly, in view of the above amendments and the following remarks, Applicants request the favorable consideration of claims 1, 2, 5-7, 15, 22, and 26.

The Office Action rejected claims 1, 2, 7, 15, 22, and 26 under 35 U.S.C. §103(a) as being unpatentable over Dubin (U.S. Patent No. 6,249,055) in view of Kim et al (U.S. Patent No. 4, 751,349). The Office Action takes the position that the combination of Dubin and Kim teach or suggest all the features of the claimed invention. In view of the above amendments and the following remarks, Applicant requests the favorable consideration of claims 1, 2, 7, 15, 22, and 26.

Claim 1 is directed to a metal interconnection buried in an insulation film. The invention comprises an interconnection material containing copper as a main component, a barrier layer formed between the insulation film and the interconnection material. The invention also comprises an adhesion layer that of Zr or ZrN formed between the barrier layer and the interconnection material. The adhesion layer is for improving the adhesion between the barrier layer and the interconnection material.

Claim 2 recites a metal interconnection buried in an insulation film comprising an interconnection material containing copper as a main component, a barrier layer formed between the insulation film and the interconnection material, and an adhesion layer containing zirconium formed between the insulation film and the barrier layer. The adhesion layer is for improving an adhesion between the insulation film and the barrier layer.

Claim 7 is directed to a semiconductor device comprising a base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate, an insulation film formed on the base substrate, the insulation film having an

opening, and a metal interconnection formed buried in the opening. The device also comprises a metal interconnection material containing copper as a main component, a barrier layer formed between the insulation film and the interconnection material, and an adhesion layer containing zirconium formed between the insulation film and the barrier layer. The adhesion layer is for improving the adhesion between the insulation film and the barrier layer.

Claim 15 recites a method for forming a metal interconnection buried in an insulation film. The method comprises the steps of forming an adhesion layer containing zirconium on the insulation film, forming a barrier layer directly on the adhesion layer, and forming an interconnection material containing copper as a main component on the barrier layer.

Claim 22 is directed to a method for fabricating a semiconductor device comprising the steps of forming an insulation film on the base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate, selectively removing the insulation film to form an opening in the insulation film and forming an adhesion layer containing zirconium on the insulation film and a region where the opening is formed. The method also includes the steps of forming a barrier layer directly on the adhesion layer, forming an interconnection material containing copper as a main component as a main component on the barrier layer so as to fill the opening, and removing the interconnection material, the barrier layer and the adhesion layer by interconnection material. The adhesion layer is for improving the adhesion between the barrier layer and the interconnection material by polishing the same until the insulation film is exposed to form the metal interconnection of the interconnection material, barrier layer, and the adhesion layer.

Claim 1 is rejected. Claim 1 recites an adhesion layer formed between the barrier layer and the interconnection material, the adhesion layer being for improving an adhesion between the barrier layer and the interconnection material. Claims 6 and 14 also recite this feature and these claims have been allowed. Since claim 1 includes the allowable feature of claim 6, Applicants request clarification of the rejection of claim 1. Further, it is submitted that the combination of Dubin and Kim fails to teach or suggest the features recited in claim 1.

Dubin discloses a metal interconnection including a Cu interconnect 54, Cu see

layer 56, TaN barrier layer 52, Al barrier layer 55, and insulating film 10. Dubin discloses using the seed layer comprising Zn or Zr as a adhesive layer. However the seed layer of Dubin is not the same as the adhesion layer as recited in claim 1. The adhesion layer of the present invention is to improve the adhesion between the barrier layer and the interconnection material, so that the barrier layer is formed between the barrier layer and the interconnection material is in contact with them. The seed layer of Dubin, however, is formed between the Cu metallization 54 and the Al or Mg alloy later 53. The seed layer 56 does not contact with the barrier layer. Therefore, the seed layer 56 in not same as the adhesion layer of the claimed invention. In addition, Dubin discloses an adhesion promoting layer 55 deposited between the barrier layer 52 and substrate 50. However, Dubin fails to teach or suggest an adhesion layer of Zr or ZrN formed between the barrier layer and the interconnection material, the adhesion layer being for improving an adhesion between the barrier layer and the interconnection material.

Kim discloses a Zr layer 44. The Zr layer 44 of Kim is formed between the Cu layer 46 and the insulating substrate 40. However, Kim fails to teach or suggest a barrier layer formed between the Cu layer 46 and the substrate 40. The Zr layer 44 is not for improving the adhesion between the Cu layer and the barrier layer, but for improving the adhesion between the Cu layer 46 and the substrate 40. Therefore, it is further submitted that there is no motivation to combine the teaching so Kim with Dubin. Accordingly, the cited references fail to teach or suggest the an adhesion layer of Zr or ZrN formed between the barrier layer and the interconnection material, the adhesion layer being for improving an adhesion between the barrier layer and the interconnection material. In view of the above analysis, Applicants submit that the features recited in claim 1 is neither taught nor suggested by the applied references.

Claims 2, 7, 15, and 22, recite the feature of a adhesion layer of Zr or ZrN formed between the insulation film and the barrier layer. The adhesion layer improves the adhesion between the insulation film and the barrier layer. Applicants submit that the applied prior art neither teaches nor suggests an adhesion layer for improving adhesion between the barrier layer and the insulation film.

Dubin discloses a metal interconneciton having Cu interconnect layer 54/seed layer 56/Tan barrier layer 42/Al adhesion layer 55 and insulating film 10. The adhesion layer 55

is not the same as the adhesion layer of the claimed invention. The adhesion layer of the claimed invention is made of Zr or ZrN. In contrast, the adhesion layer 55 of Dubin is made of Cr, TA, V or Mo. Thus, Dubin neither teaches nor suggests a Zr or ZrN adhesion layer. In addition, Dubin fails to teach or suggest a Zr or ZrN layer as being effective for improving the adhesion between the barrier layer and the insulation film.

Furthermore, the Zr layer 44 as disclosed in Kim is also not the same as the adhesion layer recited in the claimed invention. Specifically, the adhesion layer of the present invention is to improve the adhesion between the barrier layer and the insulation layer, so that the adhesion layer is formed between the barrier layer and the interconnection material is in contact with them. In contrast, the Zr layer 44 of Kim is for improving the adhesion between the Cu layer 46 and the insulating substrate 40, so that the Zr layer 44 is formed between the Cu layer 46 and the substrate 40 is in contact with the Cu layer 46 and the substrate 40. Thus, Kim fails to teach or suggest the barrier layer being formed between the Cu layer 46 and the Zr layer 44. Kim further fails to teach or suggest that the Zr or ZrN layer can be effective for improving the adhesion between the barrier layer and the insulation film.

Accordingly, Kim does not teach or suggest the feature of an adhesion layer provided between the barrier layer and the insulation film, so that the adhesion layer is formed between the barrier layer and the interconnection material is in contact with them. Therefore, the teachings of Kim does not cure the deficiencies of Dubin. In view of the above analysis, it is submitted that the combination of Dubin and Kim neither teach nor suggest all the features recited in claims 2, 7, 15, and 22. Thus, Applicant requests the withdrawal of the rejection of claims 2, 7, 15 and 22 under 35 U.S.C. 103(a).

Claim 5 was rejected under 35 U.S.C. 103(a) as being unpatentable over Dubin in view of Kim et al. and in further view of Nogami et al. (U.S. Patent No. 6, 022, 808). Applicants respectfully disagree.

Claim 5 is directed to a metal interconnection buried in an insulation film. The metal interconnection comprises an interconnection material containing copper as a main component, a barrier layer formed between the insulation film and the interconnection material and an adhesion layer. The adhesion layer contains a metal material having a solid solubility limit of not more 20% weight in copper and a resistivity increase of not more

than 19.8 % when solved in copper formed on the barrier layer and not containing copper. The adhesion layer is for improving an adhesion between the barrier layer and the interconnection material.

Nogami is directed to a copper interconnect for enhancing the electro-migration resistance. The Office Action takes the position that the seed layer disclosed in Nogami is the same as the adhesion layer of the present invention. Applicant submit that the adhesion layer as claimed in the present invention is not the same as the seed layer of Nogami. Specifically, the seed layer of Nogami is for growing the Cu layer, so that copper is contained in the seed layer. Further, Nogami discloses that the seed layer may be made of an alloy of Cu and Mg, Al, Zn, Zr, Sn, Ni, Pd, Ag, or Au. The adhesion layer of the claimed invention does not contain copper and is formed on the barrier layer. Thus, Nogami neither teaches nor suggests the adhesion layer containing a metal material having a solid solubility limit of not more than 20% weight in copper and a resistivity increase of not more than 19.8% when dissolved in copper formed on the barrier layer and not containing copper.

In addition, Nogami fails to teach or suggest an adhesion layer an adhesion layer formed on the barrier layer, thereby improving the adhesion between the barrier layer and the interconnection material. As a result, Nogami does not cure the deficiencies of Dubin and Kim. Additionally, it is submitted that it would not have been obvious to one of the ordinary skill to combine the teaching of Dubin, Kim and Nogami to teach the features of the claimed invention. Therefore, Applicant requests withdrawal of the rejection of claim 5 under 35 U.S.C. 103(a).

Claim 26 is rejected under 35 U.S.C. 103(a) as being unpatentable over Dubin in view of Kim. Claim 26 is dependent upon claim 5. As such, it is submitted that claim 26 recites patentable subject matter for at least the reasons mentioned above. Accordingly, Applicants request the withdrawal of the rejection of claim 26.

Claim 3 is objected to for being dependent upon a rejected base claim. Claim 3 is dependent upon claim 1. Applicants submit that claim 1 recites subject matter that is neither taught nor suggested by the applied references. Therefore, Applicants request the withdrawal of the objection of claim 3.

In view of the above amendments and distinctions discussed above, withdrawal of


the rejections to claims 1, 2, 5, 7, 15, 22, and 26 is respectfully requested. Further, if the Examiner persists in the rejection of claim 1, it is respectfully requested that he clarify the rejection of this claim in view of the allowance of claim 6. Claims 4, 6, 8-14, 16-21, and 23-25 are allowed. Applicants thank the Examiner for the allowance of these claims. Claims 1 and 5 are amended. No new matter is presented. It is respectfully submitted that claims 1, 2, 5, 7, 15, 22, and 26 recite subject matter that is neither taught nor suggested by the applied prior art. Therefore, Applicant submits that the application is now in condition for allowance with claims 1-26 contained therein.

Should the Examiner believe the application is not in condition for allowance, the Examiner is invited to contact Applicant's undersigned attorney at the telephone number listed below.

In the event this paper is not considered to be timely filed, Applicant respectfully petitions for an appropriate extension of time. The Commissioner is authorized to charge payment for any additional fees which may be required with respect to this paper to Counsel's Deposit Account 01-2300.

Respectfully submitted,

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Enclosures: Petition for Extension of Time
Request for Continued Examination